RESEARCH DEPARTMENT

U.H.F. field strength distributions at typical domestic receiving locations

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U.H.F. FIELD STRENGTH DISTRIBUTIONS AT TYPICAL DOMESTIC RECEIVING LOCATIONS

Research Report No. K-168

(1964/2)

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SUMMARY

The results of a series of field strength measurements made both within and in the immediate vicinity of a group of typical suburban houses are stated. Based on experience that a receiving aerial mounted outdoors at 30 ft (9·1 m) above ground level (a.g.l.) gives a satisfactory service if the ambient field strength is not less than 70 dB above 1 μV/m (70 dB(μV/m)), it is concluded that a loft-mounted receiving aerial will be satisfactory at the majority of sites where the ambient field strength is at least 76 dB(μV/m).

The practicability of indoor aerials in ground floor living rooms is more difficult to assess, being extremely dependent upon local screening effects, but it would appear unlikely that an indoor aerial will provide a satisfactory picture in areas where the ambient field strength at 30 ft (9·1 m) a.g.l. is less than 90 dB(μV/m).

Measurements of receiving aerial height-gain indicate the importance of mounting aerials as high as possible in suburban fringe areas. The scatter distribution of received field from two co-sited transmissions on different channels, and of the vision-to-sound ratios of one channel, is discussed. The vision-to-sound ratios measured over the region are analysed for comparison with the estimated transmitting aerial characteristics at sound and vision frequencies on one of the channels.

1. INTRODUCTION

This report covers an investigation of field strength distribution at ultra high frequencies (u.h.f.) in built-up areas, and is based on measurements of the BBC transmissions from Crystal Palace on Channels 34 and 44 during the period March-June 1963. A previous report[1] dealt with the effects caused by individual high buildings at u.h.f. Here we are concerned with three additional matters as follows:

(a) Receiving aerial height-gain characteristics in typical suburban areas.

(b) Use of a receiving aerial mounted in the loft or in the ground floor living room of a house ('indoor' aerials).

(c) Comparison of the effective signal strength available at an existing u.h.f. aerial installation with that expected from the standard 30 ft (9·1 m) a.g.l. measurements made in the vicinity.

In connexion with (c) above it should be remembered that when a field strength survey is made at u.h.f. the information will usually be in the form of measurements made on roads with the receiving aerial raised to 30 ft (9·1 m) a.g.l. These measurements may therefore be considered as reference values with which measurements at other heights and situations may be compared. At all individual houses visited in this investigation several field strength measurements were made at 30 ft (9·1 m) a.g.l. in the roadway fronting the house, the mean value being taken to represent the ambient field in the area.

2. TRANSMISSION CHARACTERISTICS

The transmissions measured were radiated from the BBC transmitting station at Crystal Palace with the characteristics specified in Table 1.

TABLE 1

Characteristics of U.H.F. Transmissions radiated from Crystal Palace

CHANNEL	FREQUENCY		TRANSMITTING AERIAL			NOMINAL MEAN VISION e.r.p.	NOMINAL VISION/SOUND POWER RATIO
	Vision	Sound	Type	Mean Height a.g.l.			
	Mc/s	Mc/s		ft	m		dB
34	575·25	581·25	Stacked Yagis	650	198	100 kW	7
44	655·25	661·25	Helix	690	210	110 kW	7

As discussed later, the transmission characteristics of Channel 44 differed from the specified characteristics in two respects:

(a) The measured vision-to-sound ratio was found to be significantly higher. The reason for this is thought to be a change with frequency in beam tilt of the aerial.

(b) Within a range of about 10 miles (16 km) reception conditions were somewhat unpredictable because of inadequate gap-filling of the vertical radiation pattern (v.r.p.) of the aerial.

It was known that the horizontal radiation patterns (h.r.p.s) of the two aerials differed by up to ± 4 dB depending on direction, but this was neglected in most of the measurements. As a result, the scatter in a particular series of comparison tests was probably greater than would occur had allowance been made for these differences, but the median ratio is unlikely to be affected.

3. RECEIVING EQUIPMENT

All measurements, except those inside houses, were made with a rack-mounted tunable receiver as used in the previous series of field trials.[2] At vision frequency an allowance of 5 dB was made to relate mean picture level to peak transmitter power. Indoor measurements were made with the use of two portable transistorized receivers,[3] crystal tuned to the sound frequencies of Channels 34 and 44 respectively. No measurements at vision frequency were therefore possible within the houses visited. In living rooms a two-stack dipole aerial with screen reflector was used as the receiving aerial, it being considered that this represented the most complex type of array likely to be used in these circumstances. A subsequent investigation to compare various commercial indoor aerials was later carried out, and these aerials are described in Section 6.

The aerial used for loft and external measurements was a three-element Yagi with screen reflector. For road measurements this form of aerial was mounted on a telescopic mast extending to a maximum height of 33 ft (10 m) a.g.l.

The monochrome television receiver used for the subjective assessments was a Murphy Model V 789 incorporating u.h.f. tuner Model K 789. Typical noise factors for this type of tuner are of the order of 14 dB, representative of good commercial receivers in current production.

4. RECEIVING AERIAL HEIGHT-GAINS IN SUBURBAN AREAS

4.1. General

In the v.h.f. bands it is accepted practice to refer all measured field strengths to a receiving aerial height of 30 ft (9·1 m) a.g.l., assuming the height-gain characteristic to be linear. At u.h.f. this assumption is no longer valid in built-up areas because of the increased shadow loss due to buildings. For this reason it has appeared to be necessary to measure field strength directly at the reference height of 30 ft (9·1 m) a.g.l. (The reference height in the remainder of Europe is generally 10 metres.)

Fig. 1 indicates the shadow loss of a 600 Mc/s transmission, calculated by Fresnel diffraction theory, at various receiving aerial heights behind a knife-edged obstacle at 30 ft (9·1 m) a.g.l., such as might be represented by the roof of a two-storey house. These curves have been expressed as field strengths relative to that at 30 ft (9·1 m) a.g.l., from which the theoretical receiving aerial height-gains at any distance from the obstacle can be deduced. Although these curves are of little direct application to the more complex practical situation existing in built-up areas, they do indicate that the height-gain due to shadow effects may be at least 3 dB between the heights of 25 ft (7·5 m) and 30 ft (9·1 m) a.g.l. for points less than 70 yds (63 m) from the nearest house.

For two-storey houses with external aerials mounted at chimney-stack height the available field strength may be regarded as that obtained from survey measurements at 30 ft (9·1 m) a.g.l. Prediction of field strength in lofts and ground floor rooms will, however, require the application of additional correction factors for height and for attenuation in walls and roof.

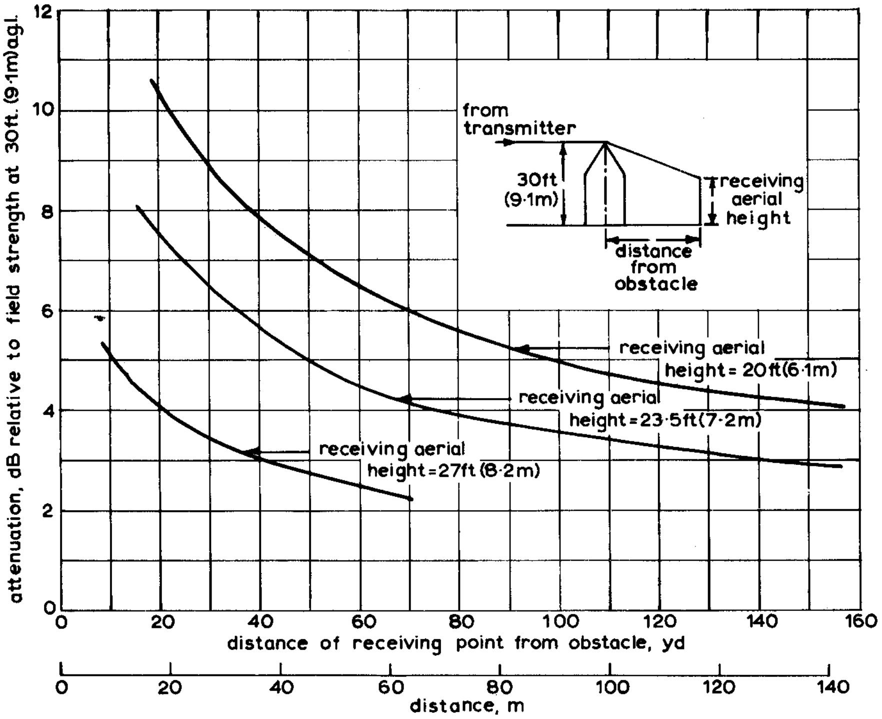


Fig. 1 - Theoretical shadow loss due to a knife-edged obstacle 30 ft (9·1 m) a.g.l. at 600 Mc/s

4.2. External Height-Gain Measurements

During the 1957/58 u.h.f. field trials the results of 1,200 receiving aerial height-gains in towns and villages were analysed. These results, previously unpublished, gave a median height-gain from 12 ft (3•7 m) to 30 ft (9•1 m) of 12 dB. Height-gain values exceeded at 10% and 90% of sites were 20 dB and 4•5 dB respectively. To check these results, and to establish the slope of the height-gain characteristic in the region of 30 ft (9•1 m) a.g.l., field strength values at spot points were measured at 10¼ ft (3•3 m), 25 ft (7•5 m), 30 ft (9•1 m) and 33 ft (10 m) a.g.l. Suburban areas of various housing densities were visited, and measurements made at random (so including a proportionate representation of measurements in open spaces). No measurements were made in the immediate vicinity of buildings greater than two storeys in height. The results, which are given in Table 2, indicate that all the towns visited have median height-gains over the range 10¼ ft (3•3 m) to 30 ft (9•1 m) lying within the range 11•5 dB to 15•5 dB, with a mean of 13•5 dB. This value agrees well with that of 12 dB mentioned above, obtained over a slightly smaller height range. Both series of measurements have similar ranges of scatter.

As predicted from Fig. 1, height-gains of appreciably greater than linear value occurred over the measured range 25 ft (7•5 m) to 33 ft (10 m), and it appears that a constant height-gain of approximately 0•7 dB/ft (2•3 dB/m) is applicable over the whole range for which measurements were obtained.

TABLE 2

Height-Gain Measurements at Different Locations

AREA	NATURE	NO. OF POINTS	HEIGHT GAIN 10¼-30 ft (3·3-9·1 m)		HEIGHT GAIN 25-30 ft (7·5-9·1 m)		HEIGHT GAIN 30-33 ft (9·1-10 m)	
			MEDIAN dB	RANGE 10%-90%	MEDIAN dB	RANGE 10%-90%	MEDIAN dB	RANGE 10%-90%
1) Ewell	Typical densely-built suburban area. Mostly semi-detached houses.	44	15·5	16·5	3·0	6·5	3·0	5·0
2) Tadworth/ Tattenham	A more hilly area than (1). Also greater distances between houses.	20	11·5	11·0	3·0	6·0	2·5	7·0
3) West Epsom/ Ashtead	Predominantly detached houses well separated and with many trees.	20	13·5	13·5	4·0	12·0	2·0	8·0
4) Chessington/ Hook	Similar to (1).	20	13·0	18·0	2·5	6·5	2·0	3·0
5) Horley	Flat country town. Building types more varied than in (1) to (4).	20	12·0	20·5	3·5	6·5	3·0	4·0
6) Crawley	Typical 'New Town' architecture, densely built in places.	41	13·5	13·5	3·0	4·5	2·0	4·0
7) Redhill	Similar to (5) but a more hilly terrain.	20	12·5	13·5	3·0	5·0	1·5	5·0
	Total	185						
	Mean		13·5	15·0	3·0	6·5	2·5	5·0

4.3. Application of Height-Gains to Measurements in Houses

The results detailed in the previous section emphasize the importance of mounting receiving aerials as high as possible, especially in fringe areas where the maximum available signal is required. If, however, the rate of height-gain in the range 25 ft (7·5 m) to 30 ft (9·1 m) a.g.l. is influenced by the shadow loss caused by adjacent buildings, then the values of field strength obtained from the average height-gains may not be typical of those obtaining in house lofts. In the idealized situation where all houses are equidistant from each other, the distance of each from the nearest obstacle will be a maximum. In such cases the shadow loss will be less than that indicated by measurements in the roadway. On the other hand, there will be many instances where, on roads radial to the transmitter, the house aerial will be more severely obstructed than an aerial in the roadway. It is therefore considered reasonable to assume that the height-gain as measured on the road is representative of that existing in the vicinity of a house, at points not shadowed by it.

5. MEASUREMENTS INSIDE HOUSES

5.1. General

Field strengths of the sound signal on Channels 34 and 44 were measured in the ground floor living rooms and lofts of sixteen houses. Where possible, subjective picture assessments were also made in the same living rooms.

A standard procedure was adopted for obtaining the measurements. Four to six points were measured in each room, according to its size. The receiving aerial was mounted at 3¼ ft (1 m) above the floor, representing a typical height for a receiving aerial mounted on a television set. The aerial was oriented for maximum received signal on each channel, and at the point of greatest signal in each room this orientation generally corresponded to the bearing of the transmitter. At less favourable positions the received signals might be considerably reduced, and were frequently picked up on different bearings, often towards a window if there was a reflecting surface such as another building or a group of trees outside.

A similar procedure was adopted for the loft measurements. In this instance the optimum orientation was generally found to correspond to the bearing of the transmitter.

The mean value of several measurements made at 30 ft (9·1 m) a.g.l. in the roadway adjacent to the house was regarded as the 'reference' field strength for the locality.

5.2. Results

For each house visited the ratios of the reference field to both maximum and mean of loft and living room values were obtained. The distribution of these ratios with respect to the percentage of locations is shown in Fig. 2 for Channel 34 and in Fig. 3 for Channel 44. The apparent attenuation of signal relative to the reference field is very similar for the two channels. Any discrepancy between the readings for Channels 34 and 44 is considered to be fortuitous, and probably due to inadequate sampling.

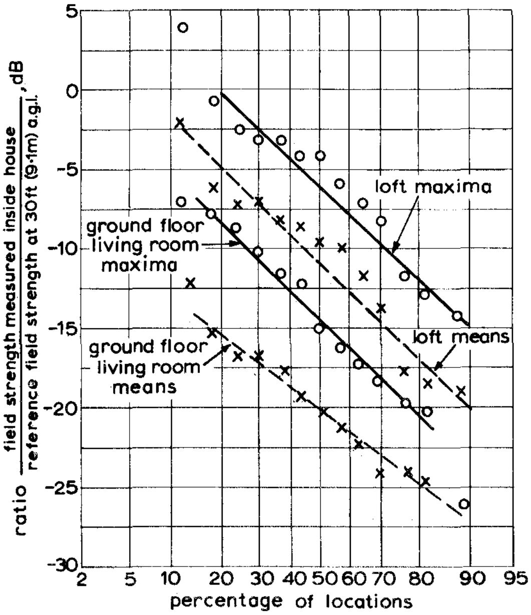


Fig. 2 - Measurements in houses: Channel 34

Field strengths measured in house lofts and living rooms relative to external reference value at 30 ft (9·1 m) a.g.l.

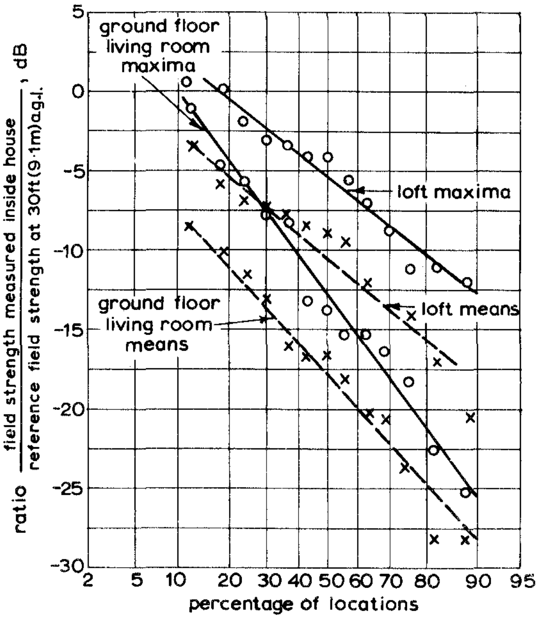


Fig. 3 - Measurements in houses: Channel 44

Field strengths measured in house lofts and living rooms relative to external reference value at 30 ft (9·1 m) a.g.l.

Taking the mean of the results obtained on the two channels, the results are as given in Table 3.

TABLE 3

Measurements in Lofts and Ground Floor Rooms

	HOUSE LOFTS	GROUND FLOOR ROOMS
Median ratio between reference field and maximum internal field	5·5 dB	13·5 dB
Median ratio between reference field and mean internal field	10·5 dB	19·0 dB

Typical heights for loft-mounted receiving aerials may be expected to be within the height range 20 to 25 ft (6 to 7·5 m) a.g.l. Allowing for a height-gain of 0·7 dB/ft (2·3 dB/m), the median field strength measured outside the house at loft height may be expected to be 3•5 to 7•0 dB less than at 30 ft (9•1 m) a.g.l. Table 3 indicates a median field strength ratio of 10•5 dB between the reference external value at 30 ft (9•1 m) and the mean value inside the loft. Consequently the loss due to attenuation in the roof material would appear to be about 5 dB. The optimum position for a loft-mounted receiving aerial was in general found to be as high as possible in the apex of the roof. Under this condition the aerial height approaches the reference height of 30 ft (9•1 m) and any reduction in received field strength may be considered as primarily due to attenuation in the roof material. The majority of measurements were made in dry conditions, and the effect of wet roofs was not investigated.

If reasonable care is taken to site a loft-mounted receiving aerial in the optimum position, the available field strength may be expected to be of the order of 6 dB less than that obtainable externally at 30 ft a.g.l. Consequently the minimum ambient field strength in which it is practicable to utilize loft-mounted aerials will be approximately 76 dB(μV/m).*

By extrapolation of the height-gain characteristic to ground floor room heights the median external field strength at 3¼ ft (1 m) a.g.l. may be expected to be about 18 to 20 dB less than at 30 ft (9•1 m). The field strengths measured in ground floor rooms are in fact greater than expected from this height-gain extrapolation, but the mean value will have been raised by the measurement procedure which included field strength maxima occurring on bearings other than towards the transmitter. The use of a receiving aerial of different directivity might appreciably influence the values measured.

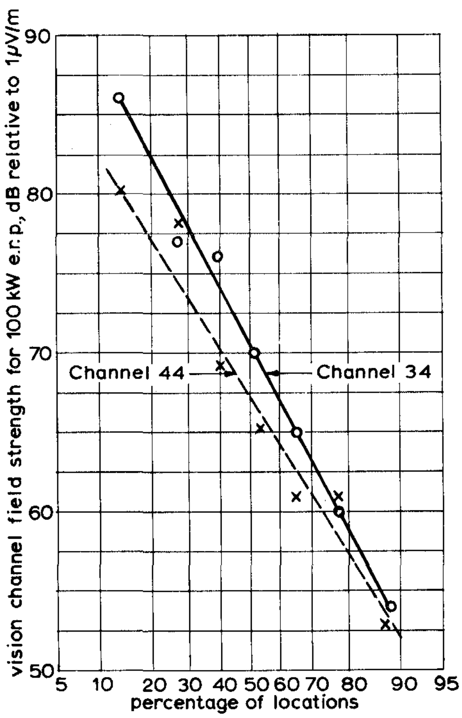


Fig. 4 - Distribution of maximum field strengths measured in ground floor house living rooms

5.3. Siting of the Receiving Aerial

After some preliminary experience, it was found to be relatively easy to predict approximately the optimum position for a receiving aerial in a living room having one outside wall facing the transmitter. The best position was generally with the aerial near this wall, and if possible sited so that the transmission path is through a window rather than through the wall itself. The optimum position of a loft aerial is not so easy to establish, but in practice optimum siting generally occurs with the aerial mounted as high as possible inside the loft. Consequently in either case, but with the exception of unfavourably sited living rooms, it is more appropriate to consider the maximum rather than the mean curves of Figs. 2 and 3.

Fig. 4 represents the distribution of maximum field strengths measured in ground floor rooms for the sample locations visited. With the aerial system and monochrome receiver used for the subjective tests, the deterioration of picture quality due to set thermal noise alone was equivalent to a grade 2 to 3 picture at 70 dB(μV/m), and grade 4 to 5 at 65 dB(μV/m). The subjective grading scale used for assessment corresponded to the following evaluations:

---

* This assumes the orientation of the loft to be such that the received signal does not traverse more than one layer of roof or wall material. It is obvious that a considerably more attenuated signal will exist in instances such as the lofts of terraced houses situated in roads radial to the transmitter.

Grade 1	Excellent	Grade 4	Rather poor
Grade 2	Good	Grade 5	Poor
Grade 3	Fairly good	Grade 6	Very poor

Fig. 4 thus shows that at between 40% and 50% of the houses visited, the available field strength at the optimum position in a room would be expected to provide a satisfactory noise-free monochrome picture. In general, multipath effects (ghosting) were not conspicuous at points where such a noise-free picture was obtainable. At other points in the room where such ghosting did occur, picture quality was generally unacceptable due to set noise. However, the greater effective radiated power (e.r.p.) proposed for the permanent service will increase the proportion of sites suffering ghosting although possessing adequate field strength to provide a noise-free picture.

6. SUBJECTIVE COMPARISONS OF THE PERFORMANCE OF COMMERCIAL U.H.F. INDOOR AERIALS

6.1. General

To confirm the subjective assessments stated in the previous section, and to compare the performance of various commercial indoor aerials, a supplementary investigation was carried out at a selected group of house living rooms. These were chosen in localities where there was a reasonable probability of a satisfactorily noise-free picture being obtainable at ground floor level. At the time of the tests only the Channel 44 transmission was available, and all subjective assessments were made on a monochrome receiver. Because of the anomalous vision-to-sound ratios previously discussed, discrepancies may be introduced when deriving equivalent vision field strengths from measurements made at the sound frequency. Where possible suitable corrections have been applied to reduce these errors.

6.2. Equipment

The aerials were as follows:

(a) *Tricraft Model 220 (American)*

This aerial comprises a vertical stack of two cylindrical dipoles backed by a lattice screen reflector. Although physically more compact, this aerial is similar to that used in the indoor tests described in Section 5.

(b) *Telefunken U.H.F. Heimantenne (German)*

This aerial is also a vertically disposed two-stack array, but built inside the plastic shade of a table lamp.

(c) *Füba Model F.I.A. IQ2 (German)*

This consists of two folded dipole elements of unequal length mounted in a horizontal plane.

(d) *Kathrein V.H.F./U.H.F. Model 4395 (German)*

This is a multiband aerial arranged such that connexions to a u.h.f. dipole may be switched to represent a folded dipole at Band III frequencies.

(e) *Hilo Model 202 (American)*

This is also a multiband aerial. The u.h.f. element consists of a cylindrical dipole; this is surrounded by, but insulated from, a 12-turn helix.

Each aerial was provided with a short length of 300-ohm balanced twin feeder terminated in a matching element transforming to a 70-ohm coaxial feed suitable for connexion to field strength and television receivers.

Measured h.r.p.s of these aerials at Channel 44 are shown in Fig. 5. At this frequency the pattern of the Hilo 202 has a minimum in the forward direction. Consequently, this aerial was oriented so that one of the radiation pattern maxima was directed towards the transmitter.

The field strength receiver was calibrated with each of the aerials to be used by comparing the receiver input voltage measured at a site in open terrain with that obtained using a Yagi aerial of known characteristics. This calibration was repeated at several sites and a mean value for the effective gain of each aerial with its associated feeder was obtained. These mean values are given in Table 4.

TABLE 4

Relative Gains of Commerical U.H.F. Indoor Aerials

AERIAL	OPTIMUM GAIN RELATIVE TO DIPOLE
(a) Tricraft 220	+4·0 dB
(b) Telefunken U.H.F. Heimantenne	+1·5 dB
(c) Füba F.I.A. IQ2	+3·0 dB
(d) Kathrein V.H.F./U.H.F. 4395	0 dB
(e) Hilo 202	+1·0 dB

The above values show appreciably higher effective gains for aerials (d) and (e) than those recorded in Fig. 5. This is attributed to the effect of the feeder, whose positioning was found to affect the aerial performance substantially. When

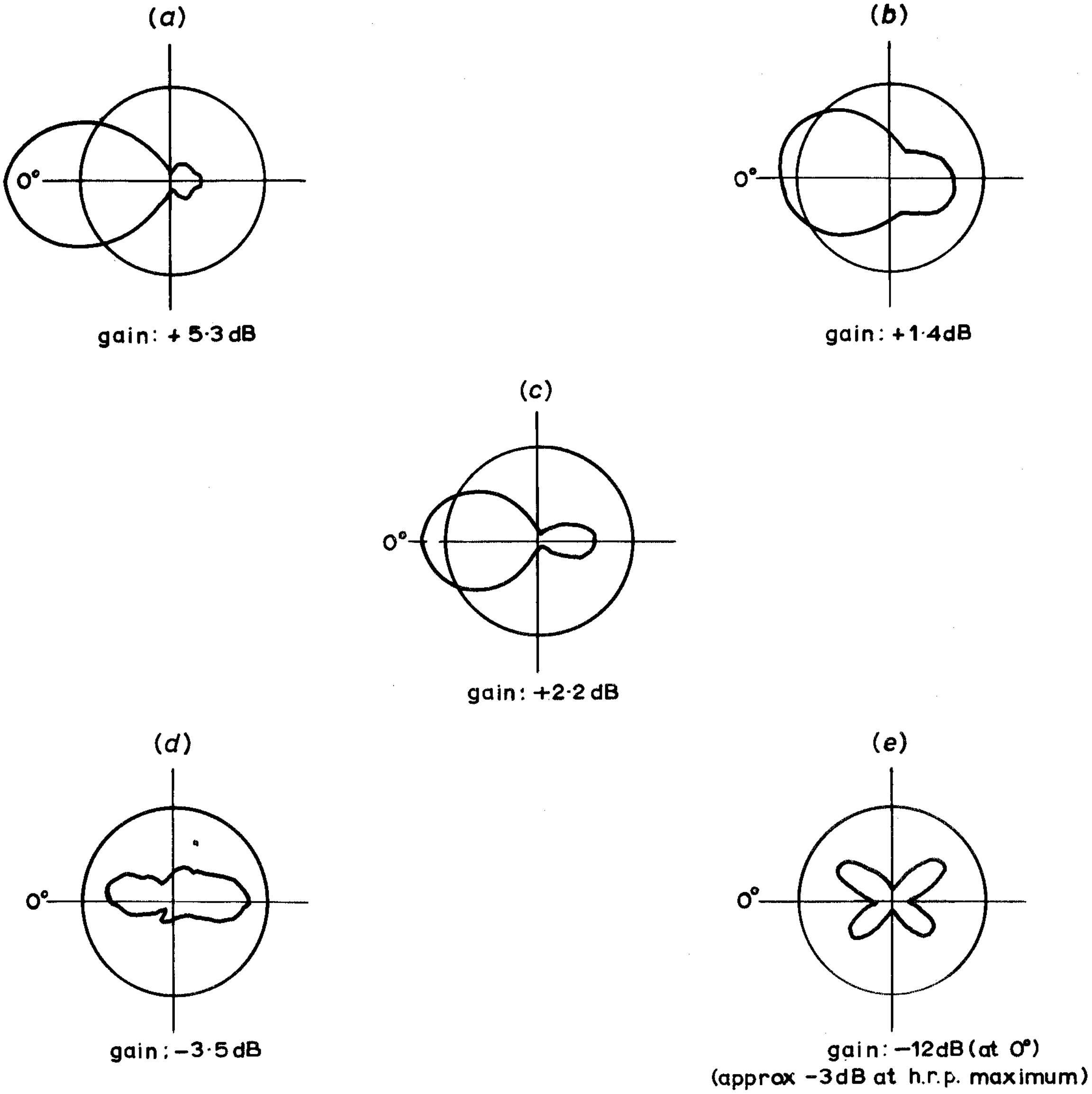


Fig. 5 - Horizontal radiation patterns and gains of commercial u.h.f. indoor aerials at 666 Mc/s

Each circle represents the maximum signal strength received from a half wave dipole

(a) Tricraft Model 220
(b) Telefunken Heimantenne
(c) Füba Model F.I.A. IQ2
(d) Kathrein Model 4395
(e) Hilo Model 202

selecting the optimum aerial positions for the subjective comparisons, it was also possible to find an optimum feeder position, thereby frequently increasing the signal measured by as much as 3 dB. This effect was less noticeable for the higher gain aerials (a), (b) and (c). The gain values quoted in Fig. 5 were obtained with the feeder position adjusted for minimum influence upon the h.r.p., but it was felt that this situation would not be typical of that occurring at the average domestic site, and hence that it might be more realistic to accept the gain values given in Table 4.

6.3. Procedure

Subjective picture quality assessments and measurements of sound frequency field strength were made with all five aerials at one or more points in the living rooms of the houses and flats visited. The aerials were, in turn, placed on some suitable surface at a height of 3 ft (0·9 m) to 4 ft (1·2 m) and then adjusted for maximum input to the field strength receiver by orientation and lateral displacement over a small area. Picture quality was then assessed on the television receiver, the aerial being re-checked for optimum position if necessary. The purpose of this second adjustment of the aerial was to minimize any discrepancies due to differences between the field strength standing wave structure at sound and vision frequencies.

Table 5 represents the gradings assessed at the various houses visited. Where more than one position was investigated in any house the suffix (x) represents the position expected from experience to provide the best picture. Unless otherwise specified, all sites are ground floor rooms.

Half grade assessments were made at points where a decision between adjacent grades was difficult to make. It was found that use of the aerials of poorest directivity ((d) and (e)) rendered the picture appreciably more susceptible to 'flutter' effects caused by people moving in the vicinity of the aerial. Since assessments were made under static conditions this effect did not affect the gradings obtained.

6.4. Results

For each location visited the vision field strength was derived from the measurement made with each aerial tested. Due to the complexity of the local field standing wave pattern, to the difference in receiving aerial h.r.p.s, and to the fact that each aerial was individually placed in the optimum position, the apparent field strengths as measured with the various aerials are not identical at nominally identical points. Table 5 gives the mean field strength at each point, together with the overall range of scatter of the individual values from which the mean is obtained. The reference field strength, i.e. the ambient external field strength at 30 ft (9·1 m) a.g.l., is also tabulated for each site.

Considering only the results obtained at the preferred (x) sites, the median ratio between reference field strength and that measured at ground floor level is 19 dB. This corresponds to the mean rather than the maximum ratio in Table 3 of the previous section.

6.5. Correlation of Picture Grade with Field Strength

The picture grading assessed at all locations was determined primarily by the presence of receiver thermal noise. It is therefore to be expected that a close

TABLE 5

Subjective Assessments of Picture Quality (Indoor Aerials)

SITE	PICTURE GRADE ASSESSED FOR DIFFERENT RECEIVING AERIALS					MEAN VISION FIELD STRENGTH dB(μV/m)	FIELD STRENGTH SCATTER dB	REFERENCE FIELD STRENGTH† dB(μV/m)
	TRICRAFT (a)	TELEFUNKEN (b)	FÜBA (c)	KATHREIN (d)	HILO (e)			
(1)	5	5	6	6	5	65·5	12	84
(2)*	2	2	2½	3	2	70·5	4	85
(3x)	1	1½	1	1½	2	80	4	95
(3y)	2½	3½	3½	4½	3½	70·5	3	95
(4x)	2	3½	2½	2½	3½	73	4	75
(4y)	3½	5	3½	5	3½	69	8	75
(5x)	5	5½	5½	6	5	63·5	3	85
(5y)	4	5	4	5	5	68	0	85
(6)	3	3½	4	5	5½	68·5	5	88
(7x)	2	2	2	4	2½	74	6	101
(7y)	4½	4½	5	5	4	67	10	101
(8x)	1½	3	3	3	3½	74	4	102
(8y)	1	1½	2	2½	3	78	2	102
(9x)*	1	1	1	1	1	81	2	98
(9y)*	5	6	4	6	5	67·5	7	98
(10x)	3½	3	3	3½	4	74	5	95
(10y)	5	4	5	5	3½	71	7	95
(10z)	5	5	5	6	5	71	6	95
(11x)	2	3	2	3	3½	77	6	95
(11y)	5	5	5½	6	5	65	4	95
(12x)	2	2	2	3½	2½	77	2	88
(12y)	2½	3	3	4	3½	73	7	88

† Measured externally at 30 ft (9·1 m) a.g.l.

* First floor living rooms

correlation will exist between grading and field strength. Figs. 6(a) to 6(e) represent plots of picture grade versus vision field strength. On these plots are superimposed the best fit linear approximations, obtained by the Method of Least Squares. For the purpose of comparison, these best-fit lines are re-drawn in Fig. 6(f). From this figure is derived Table 6 below, indicating limiting field strengths for a marginally acceptable picture quality.

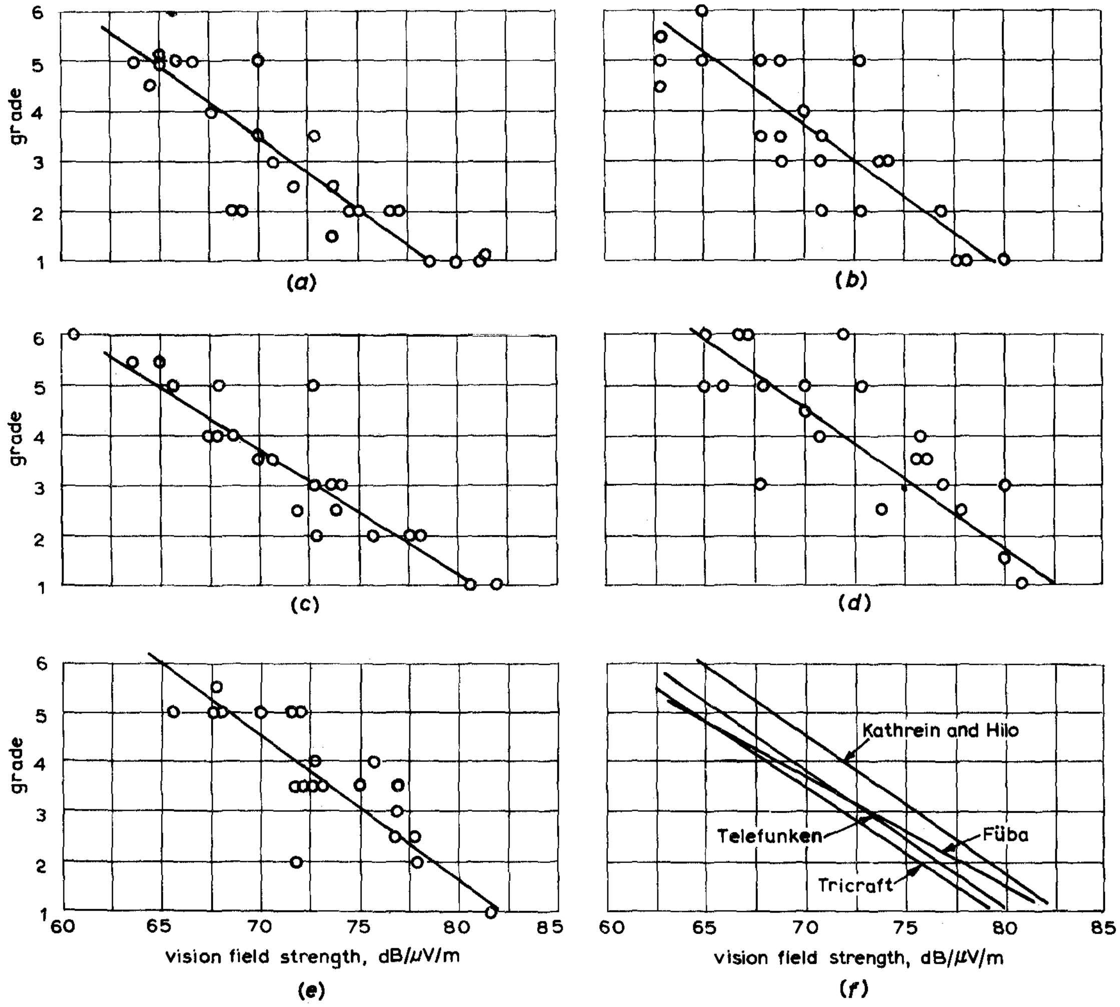
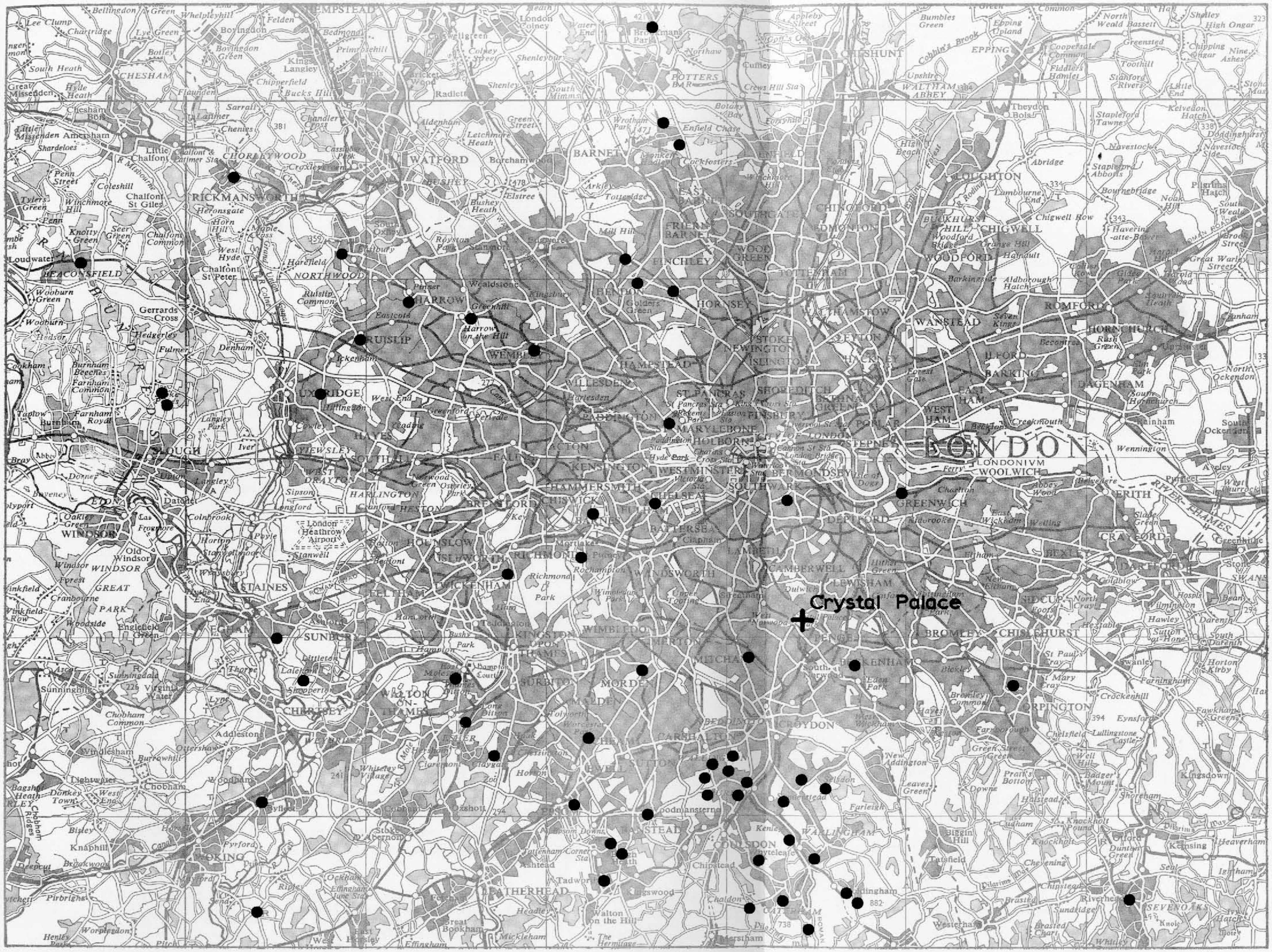


Fig. 6 - Correlation of subjective grade with field strength for indoor u.h.f. aerials

(a) Tricraft Model 220
(b) Telefunken Heimantenne
(c) Füba Model F.I.A. IQ2
(d) Kathrein Model 4395
(e) Hilo Model 202
(f) Comparison of aerials



Scale: 4 miles to 1 inch (approx)

Topographical information based upon the Ordnance Survey map with the sanction of the Controller of H.M. Stationery Office. "Crown Copyright reserved".

Fig. 7 - Location of domestic receiving sites visited

TABLE 6

Field Strengths Required for Grade 3 and Grade 4 Reception

AERIAL	GAIN dB	FIELD STRENGTH FOR GRADE 3 (FAIRLY GOOD) PICTURE QUALITY dB(μV/m)	FIELD STRENGTH FOR GRADE 4 (RATHER POOR) PICTURE QUALITY dB(μV/m)
(a) Tricraft	4	72	68•5
(b) Telefunken	1•5	72•5	69•5
(c) Füba	3	73	69•5
(d) Kathrein	0	75•5	72
(e) Hilo	1	75•5	72

It may be seen that, as expected, the limiting field strength for a particular grade of picture is closely related to the aerial gain.* To some extent the fact that all assessments were made in daytime might be expected to reduce the correlation between picture grade and field strength. The perceptibility of set thermal noise is dependent upon the setting of the contrast control. Both contrast and brilliance controls were adjusted to give the most satisfactory picture at each location. However, these settings were not solely determined by the level of signal input to the set, but also by the ambient illumination on the screen, which varied from site to site. A similar series of assessments carried out under uniform, and more typical, conditions of artificial illumination might improve the correlation between field strength and picture degradation due to set noise.

It should, however, be emphasized that this particular investigation was of limited scope, the gradings being determined by one observer and using one domestic receiver throughout. A more extensive investigation with several observers might well be expected to yield results with a much greater range of scatter.

7. THE PERFORMANCE OF EXISTING DOMESTIC U.H.F. AERIAL INSTALLATIONS

7.1. General

A group of approximately 60 houses was visited, each provided with an external or loft-mounted u.h.f. aerial. The location of the sites is indicated by Fig. 7, from which it will be seen that a reasonably representative distribution was obtained over the western half of the service area. The aerials installed were either 6- or 10-element double-stack Yagi arrays, with aerial gains and feeder losses as shown in Table 7.

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* Typical fringe area receiving aerial gains, after allowance for feeder losses, may be expected to be of the order of 8 to 10 dB. Normalizing the values given in Table 5 to this aerial gain, the limiting field strength for a grade 3 service is approximately 66 to 68 dB(μV/m). Since the receiver used possessed a good, rather than average, noise factor, this result is consistent with the value of 70 dB(μV/m) as a suitable service area boundary for planning purposes until such time as receivers with improved noise factors become generally available.

TABLE 7

Characteristics of Aerials used at Domestic Receiving Locations

	CHANNEL 34	CHANNEL 44
Aerial gain 6-element double stack	9·5 dB	10·0 dB
Aerial gain 10-element double stack	11·5 dB	12·0 dB
Feeder loss 60 ft (18·2 m) ET10M*	6·0 dB	6·5 dB

* Increased by 1 dB for effect of weathering on feeder.

These values were utilized to relate the voltage measured at the receiver input to the equivalent field strength existing at the aerial.

7.2. Results

Detailed information about the individual sites visited is given elsewhere;[4] this report considers three particular aspects of the distribution.

7.2.1. Vision-to-Sound Ratios

The result of an analysis of vision-to-sound ratios measured at the locations visited is represented in Fig. 8. In view of the small number of samples

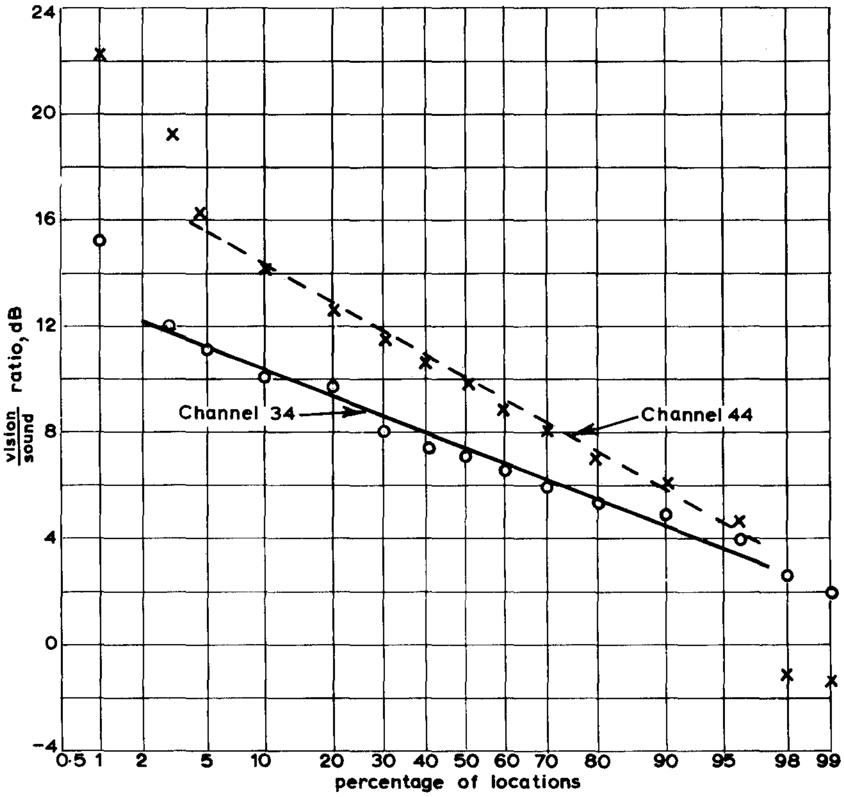

Fig. 8 - Vision-to-sound ratio distribution for all points measured

available, the 'best fit' linear approximation is not extended beyond the limits 5% to 95% although it is considered that the non-linearity of the Channel 44 distribution at extreme limits is a genuine effect due to lack of gap-filling in the transmitting aerial v.r.p. rather than to inadequate sampling.

Fig. 8 indicates that on Channel 34 90% of samples have vision-to-sound ratios within the limits 7½ ± 3 dB, whereas on Channel 44 the corresponding range is 10 ± 5½ dB. To investigate the effect of transmitting aerial v.r.p. upon the vision-to-sound ratio, the results were grouped into those relating to sites less than 10 miles (16 km) and more than 10 miles (16 km) from the transmitter. The results of these groupings are shown in Figs. 9 and 10. These figures show that whereas the distribution of ratios relating to Channel 34 is independent of distance, that relating to Channel 44 is substantially different in the two instances. At distances greater than 10 miles (16 km) the range of scatter for Channel 44 is comparable with that of Channel 34, with a median value of 9 dB, whereas at points less than this distance the median value is of the order of 12 dB. This is consistent with the known v.r.p.s of the two aerials; the aerial for Channel 34 was gap-filled, whilst that for Channel 44 was not.

Fig. 10 indicates that even in outer areas, where differential effects due to lack of gap-filling should not be present, the Channel 44 vision-to-sound ratio is apparently greater than its nominal value; the measured ratio between the channels is seen in Fig. 10 to be 1½ dB. There is reasonable agreement between this ratio and an estimate based on the expected performance of the transmitting aerials. The beam

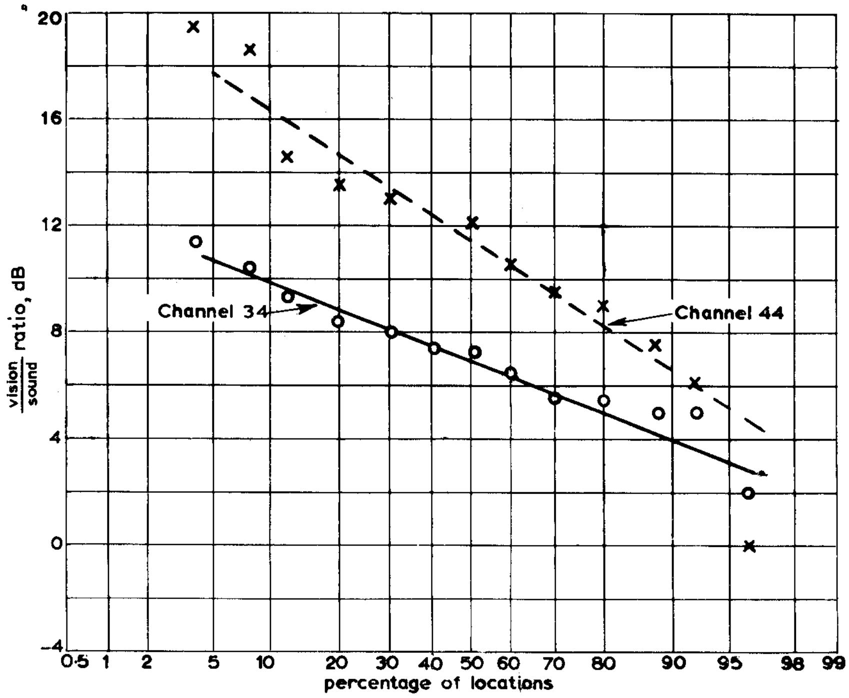

Fig. 9 - Vision-to-sound ratio distribution for locations less than 10 miles (16 km) from the transmitter

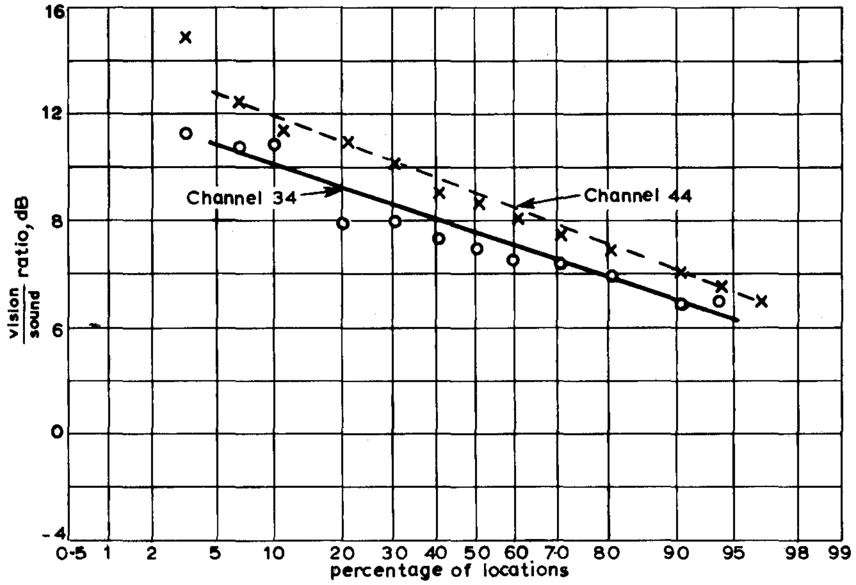

Fig. 10 - Vision-to-sound ratio distribution for locations more than 10 miles (16 km) from the transmitter

tilt of the Channel 44 aerial changes slightly with frequency, whereas that of the Channel 34 aerial does not.

7.2.2. Comparisons between Field Strengths Measured on Domestic Aerial Installations and Adjacent External Points

Fig. 11 shows the distribution of the ratios of the signals received at the two sound-channel frequencies, as measured both on the house aerial installations and externally at 30 ft (9·1 m) a.g.l. in the roadway. Although the series of measurements made on house aerials shows a slightly greater range of scatter, the discrepancy is not thought to be significant in view of the small number of samples, and is probably due to inaccurate alignment of some of the domestic aerials. Fig. 11 indicates that for 90% of the sites visited, the Channel 34 sound field strength exceeds that of Channel 44 by a ratio within the limits 5 ± 8 dB. The range of scatter is similar to that obtained from an earlier series of measurements employing a larger number of samples.[5]

The effect of abnormalities in the Channel 44 transmitting aerial characteristics upon the sound channel e.r.p. is discussed in the previous section. After correction for these it would appear that differential propagation effects may be appreciable, favouring the lower frequency transmission. The degree of uncertainty relating to the respective transmitting aerial characteristics and to the influence of different transmitting aerial heights does not allow a quantitative evaluation of such propagation effects to be established.

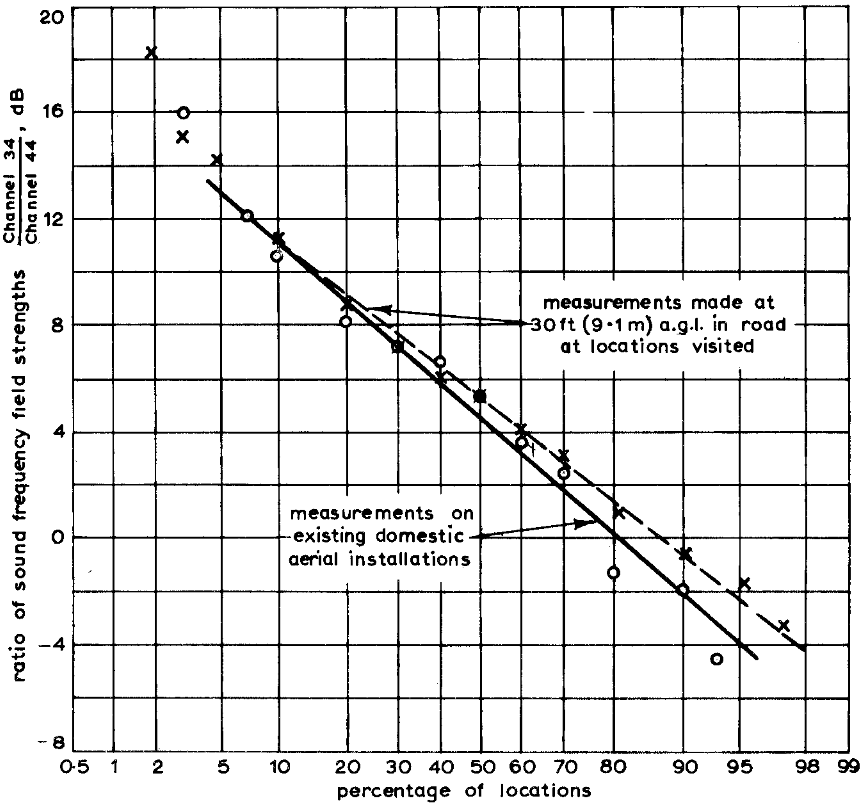

Fig. 11 - Distribution with location of ratios of field strength measured on Channels 34 and 44

7.2.3. Reception of Two Co-Sited Transmissions at Individual Receiving Locations

Fig. 12 gives the same information as in Fig. 11, but neglecting points less than 10 miles (16 km) from the transmitter and with the distribution normalized by adjusting the ordinate scale such that the median ratio is zero.

This figure may be considered in terms of a probability distribution. Table 8 specifies the field strength of either channel at any location which must be exceeded for a given probability that the field strengths of two transmissions having the same median value will both exceed a specified value.

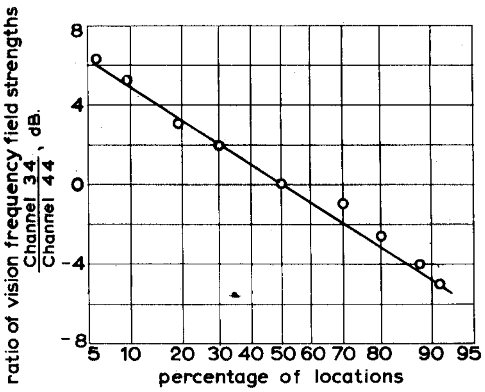

Fig. 12 - Distribution with location of ratios of field strength measured on Channels 34 and 44 derived from Fig. 11 with corrections for differences in transmitting aerial characteristics and normalized for equal e.r.p.s

TABLE 8

Probability of Satisfactory Reception of Two Co-Sited Transmissions for Specified Field Strength

% PROBABILITY THAT THE FIELD STRENGTH WILL EXCEED E dB ON BOTH CHANNELS	FIELD STRENGTH WHICH MUST BE EXCEEDED ON ONE CHANNEL
95	E + 6 dB
90	E + 5 dB
80	E + 3 dB
70	E + 2 dB
60	E + 1 dB
50	E + 0 dB

If two services are to be provided from co-sited transmitters separated in frequency by a channel spacing comparable to that used in these tests, it may then be appropriate to make some suitable allowance when delineating the extent of the area served. Thus for example, if a field strength of 70 dB(μV/m) be considered to be the minimal field providing an adequate service, then in order to ensure 70% probability that any location will receive this field strength on both transmissions the field strength of one transmission must be not less than 72 dB(μV/m).

8. CONCLUSIONS

The first section of the investigation emphasizes the importance of mounting the receiving aerial as high as possible, particularly in suburban fringe areas. Use of the Continental receiving aerial height of 10 metres, rather than the United Kingdom standard of 30 ft (9·1 m) a.g.l., might be expected to result in an increase of 2 dB in the median field measured in many built-up areas. This difference may be of significance when comparing field strength distributions measured in the United Kingdom with those obtained by Continental organizations.

The median loss to be expected when an aerial is mounted as high as possible in a loft will be of the order of 5 to 6 dB relative to an outdoor aerial at 30 ft (9·1 m) a.g.l. This result is in agreement with that obtained from a similar series of measurements in the course of the previous field trials.[6]

In ground floor living rooms the situation is more difficult to assess, since local conditions vary considerably at individual sites. The first series of tests described here indicated a median reduction of 13 to 14 dB relative to that obtainable with an outdoor aerial at the standard height. This value appeared optimistic in terms of the extrapolated height-gain characteristic, and the second series of indoor measurements indicated a greater reduction in available field strength. It is therefore probable that indoor aerials will not generally be satisfactory at ground floor level in built-up areas where the ambient field strength at 30 ft (9·1 m) a.g.l. is less than 90 dB(μV/m). Such aerials may be expected to be of greatest utility in rural areas and on the higher floors of blocks of flats.

With the present plan for high power u.h.f. transmitters there will be many urban areas of high population density where the ambient field strength at 30 ft (9·1 m) a.g.l. will exceed 90 dB(μV/m); for example, this will apply to a population of several millions in the London area. It must therefore be expected that a substantial proportion of u.h.f. viewers may be content to use an indoor aerial, accepting a picture quality of grade 1, 2 or 3. However, there is no doubt that in many cases where a grade 2 or 3 picture is obtained with an indoor aerial, an improvement to grade 1 or 2 would be obtained by the use of a directional outdoor aerial, the improvement being largely due to the better signal-to-noise ratio and to a lesser deterioration of picture quality due to short or long delay echoes.

The subjective comparisons of the various commercial indoor aerials, all made with monochrome reception, emphasize the advantage of the higher gain aerials in improving the signal-to-noise ratio in the receiver. Good aerial directivity was also advantageous in reducing 'flutter' effects caused by the movement of people in the vicinity of the aerial. Of the aerials tested, the poorest in performance at u.h.f. were the multiband models. The 'multiband facility' appears to be of little merit in the United Kingdom where many of the major v.h.f. transmitters use vertical polarization, and receiver manufacturers design their sets with separate aerial input sockets at v.h.f. and u.h.f.

A more stringent criterion of the field strength limiting a service area is required where two or more co-sited transmissions are to be received on a common aerial at all locations. However, at present no such allowance is made in the comparable situation existing on the BBC Band II transmissions.

Comparative measurements of the Channels 34 and 44 transmissions show some evidence that differential propagation effects may be significant. The conditions of the test do not, however, permit the extent of this difference to be specified.

9. ACKNOWLEDGEMENT

The ready co-operation of all those whose houses were visited in this investigation is gratefully acknowledged.

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